California Public Utilities Commission

POLICY AND PLANNING DIVISION

&

SAFETY AND ENFORCEMENT DIVISION

OFFICE OF UTILITY SAFETY AND RELIABILITY

Quantifying Risk:

Building Resiliency into Utility Planning

Richard White
Principal Author
POLICY AND PLANNING DIVISION

Elizaveta Malashenko
Deputy Director
SAFETY AND ENFORCEMENT DIVISION

JANUARY 23, 2014

Contents

DISCLAIMER

This White Paper was prepared by California Public Utilities Commission (CPUC) staff. It does not necessarily represent the views of the CPUC, its Commissioners, or the State of California. The CPUC, the State of California, its employees, contractors, and subcontractors make no warrant, express or implied, and assume no legal liability for the information in this White Paper. This White Paper has not been approved or disapproved by the CPUC, nor has the CPUC passed upon the accuracy or adequacy of the information in this White Paper.

Acknowledgements

Marzia Zafar – California Public Utilities Commission

Ken Bruno – California Public Utilities Commission

John Lathrop – Innovative Decisions

Alan Lamont – Lawrence Livermore National Laboratory

Tom Edmunds – Lawrence Livermore National Laboratory

Jeff Stewart – Lawrence Livermore National Laboratory

I. Executive Summary

Building safety into utility networks has been and remains a core objective for both utilities and regulators. Historically safety has been assured through compliance-based regulations. Compliance simply means conforming to a rule, such as a regulation, policy, standard or law. Risk management is increasingly recognized as a method that regulators and utilities can use to develop more robust and strategically focused safety programs. At the most basic level, risk management practices are not in conflict with compliance-based regulation, rather they are complimentary.

This "risk-based" approach to safety regulation focuses on quantifying risk and incorporating this type of assessment and evaluation into utility and regulatory decision making. While many of the existing regulations rely on risk management principles, a comprehensive framework is needed in order to be able to assess the overall risk profiles of utility operations and to enable regulators to make informed decisions on behalf of consumers.

II. Introduction: Why safety matters

In September 2010 a natural gas transmission pipeline ruptured in San Bruno. The National Transportation Safety Board's investigation found that

> "… the rupture of Line 132 was caused by a fracture that originated in the partially welded longitudinal seam of one of six short pipe sections, which are known in the industry as "pups." The fabrication of five of the pups in 1956 would not have met generally accepted industry quality control and welding standards then in effect, indicating that those standards were either overlooked or ignored. The weld defect in the failed pup would have been visible when it was installed."[1]

The explosion that occurred rocked a neighborhood, caused the death of 8 people, and devastated a community. The magnitude of the explosion was visible for miles - at first it was thought to be a plane crash or gas station fire. It quickly, however, became clear that the ongoing fireball was being fed not by jet fuel, but by an out of control underground gas pipeline.

The San Bruno tragedy exposed many things about how we develop, operate, and maintain our infrastructure. In the wake of the incident, the condition of a 50 year old pipeline initially drew attention, but the declining condition of the nations' infrastructure had already been well documented as many high profile infrastructure failures have drawn attention to that issue.[2] The San Bruno accident raised new concerns over how effective the utilities and the CPUC were at managing and assuring the integrity of this aging infrastructure. Specifically, the San Bruno tragedy raised questions about inspection standards, operational effectiveness, managerial oversight, training standards, and records

---

[1] NTSB Report issued August 30, 2011. http://www.ntsb.gov/doclib/reports/2011/PAR1101.pdf

[2] In 2007 the I-35W Mississippi river bridge crossing Minneapolis failed killing 13 people and focused nationwide attention on the state of our infrastructure. Also See American Society of Civil Engineers (ASCE) "Failure to Act Report Card: 2013" (available at http://www.infrastructurereportcard.org/grades/)

retention. More pointedly and broadly, however, is the lingering question of how do the utilities and the CPUC manage and value safety itself?

Recently the question of who is responsible for safety has arisen. When the city of San Carlos learned that gas pipelines running through their community may not have been tested properly, the city sought and received an emergency injunction ordering the pipeline shutdown. The judge who made the order was not a safety regulator but a superior court judge.[3] In the wake of this ruling, the city also hired a consultant to help with the safety investigation of the pipeline, perhaps in the belief that the safety regulator needed an overseer.[4]

The electricity sector is not immune from evolving safety concerns as well. In 2012, tubes in the recently installed steam generators ruptured in the San Onofre Nuclear power plant. While there were no injuries caused or any significant level of radioactive material released by this event, public opinion on safety found new relevance. In 2013, Southern California Edison decided to permanently shut down the San Onofre power plant. In this case, a nexus of uncertainty surrounding the safe operation and performance of critical components and the expected long-term costs associated with mitigating those risks led to the closure of the plant. [5]

These single events can have significant impacts to a localized region, but on November 13, 2012 Superstorm Sandy raised the specter of new and emerging threats. The storm knocked out power to over 8 million customers across a broad range of the northeast region. The outages impacted 50% of customers in New Jersey, 25% in Connecticut, and 21% in New York[6]. The recovery mobilized thousands of people, drawing utility workers from regions as far away as California. Even though the utilities had coordination plans established prior to the event, the slow recovery raised questions about how these plans were vetted. They also raised questions about what role regular maintenance standards, such as power line tree trimming, may have played in contributing to the scale and scope of the outages in the first place.[7] Overall, Superstorm Sandy highlighted that the interaction of several types of risks (*e.g.* climate, operations and maintenance, and systems infrastructure limitations) can lead to unpredictable and highly undesirable outcomes that threaten and degrade the resiliency of electric, gas and water networks.

Though California does not face this type of hurricane threat, we nonetheless do experience several types of natural events -- earthquake, fire, drought, and flood -- that can test the resilience of our infrastructure and the institutions that manage them. In the Sierra Nevada Mountains in the summer of 2013, the Rim fire burned part of the Yosemite National Park and threatened the Hetch Hetchy

---

[3] See San Jose Mercury News October 4, 2013 http://www.mercurynews.com/breaking-news/ci_24245177/san-carlos-judge-orders-pg-e-shut-down

[4] See San Francisco Examiner 10.16.2013 http://www.sfexaminer.com/sanfrancisco/san-carlos-to-spend-250000-on-pipeline-consultants/Content?oid=2604761

[5] See SCE's Decision to Retire San Onofre Units 2 & 3: Economic Considerations http://www.songscommunity.com/docs/Economic_Considerations_WhitePaper_Final.pdf

[6] See US- DOE situation report from Oct 31 2012 http://energy.gov/sites/prod/files/2012_SitRep7_Sandy_10312012_300PM.pdf

[7] See New York Times article Nov 13 2012 http://www.nytimes.com/2012/11/14/nyregion/long-island-power-authoritys-flaws-hindered-recovery-efforts.html?_r=0

Reservoir, its power generating station, and electrical transmission lines. Even though the fire burned in the mountains, a critical element of the water and power supply of San Francisco, 200 miles to the west, was threatened.[8]

III. Regulating Safety

Improving the safety, security and resilience of our utility networks is an unassailably desirable goal. The complex, integrated and interrelated nature of these networks, however, generates many types of potential safety hazards. Downed power lines, transformer fires, small gas line leaks, and water contamination are known hazards that are experienced regularly and can pose a direct threat to both public safety and to utility employees. In addition, power outages also pose an indirect threat to personal health and safety such as when the loss of power to a medical refrigerator threatens the viability of medical supplies. Perhaps even more important, utilities also face unknown hazards; these are hazards that we have not yet experienced but might someday in the future. In the most extreme cases, the confluence of these direct, indirect, and unknown threats can result in catastrophic and tragic outcomes such as San Bruno and Superstorm Sandy.

Challenges with Safety Regulation

Building safety into utility networks is a core objective for both utilities and regulators. Historically safety has been assured through compliance-based regulations. This approach to safety assurance is predicated on a set of rules, such as engineering specifications, against which a utility is monitored and assessed.

In some situations, "compliance" has acquired a negative connotation of "checking the box". In other words, there is a concern that regulated entities in some cases blindly follow established rules to meet the minimum requirements instead of actively managing safety risks. This concern also applies to regulators, who may be limiting themselves to looking for compliance with existing regulation, rather than focusing on preventing future problems. In this context, risk management should be seen as an extension to existing compliance-based regulation that is designed to address safety issues before they arise.

It is important to note that "compliance" itself is not fundamentally the problem. Rather, there are two issues at hand here. First is the effectiveness of rules and regulations in mitigating the safety risks that they are intending to address. In other words, are the rules that the entities are supposed to comply with adequate? Second is the nature of the safety culture at both regulated entities and regulatory agencies. Without a culture that recognizes safety as the underlying principle for operation and achieving of objectives, no regulation or risk management framework will achieve the needed results.[9]

---

[8] See LA Times 8.24.2013 http://www.latimes.com/local/lanow/la-me-ln-yosemite-fire-san-francisco-power-rim-fire20130823,0,1157539.story#axzz2nNgA64EC

[9] The CPUC initiated a Rulemaking (R.13-11-006) to develop a risk-based decision-making framework to evaluate safety improvements in utility GRC. This step will integrate a risk-based decision making process for utility rate requests (i.e. when a utility requests for a rate adjustment the request must include testimony on how additional investment will mitigate risk of an incident).

While compliance-based regulation has been effective at establishing a minimum for safety practices, it is not flexible enough to address evolving standards and conditions or to mitigate unanticipated incidents. More importantly, compliance-based regulation does not promote a culture where safety risks are actively managed. Without a process for the continual assessment and quantification of current risks, compliance-based regulation becomes a merely prescriptive process where the mission is compliance with safety rules, in contrast to actually minimizing the number and severity of safety incidents. Some of the key deficiencies of compliance-based regulations include:

Limited to known or experienced risks: Compliance-based regulation is predicated on the knowledge learned from having experienced certain kinds of risks. By design, this approach to regulation assumes that past performance is an indicator of future events. While this is often a reasonable assumption for many types of "known" and "experienced" risks, there are also known but "unexperienced" risks. The risk that may result from a nuclear weapon detonated in or above the earth's atmosphere to create an electromagnetic pulse is an example of a known risk that has not yet been experienced. Additionally there are "unknown" risks which have neither been experienced nor are easily foreseeable. For example, the resilience of networks to extreme weather events, the replenishment rate of water supplies in the face of changing weather patterns, the reliability of the grid as intermittent generation becomes more ubiquitous, and the vulnerability of grid operations against adversary driven cyber threats are all risks that are not well defined and are also unexperienced on the utility scale. The engineering design focus of many compliance-based regulations is not best suited to characterizing and managing these types of unknown and unexperienced events.

Limited to a single threshold - "Pass/Fail" - decision-making: Compliance-based regulation is based on evaluating the safety of equipment, projects and processes on a simple pass/fail criterion. This restrictive evaluation method prevents regulators and program managers from considering the effectiveness and the feasibility of a project as a whole and then making considered tradeoffs among competing alternatives. Having the option to consider tradeoffs may seem antithetical to compliance-based regulations, but the lack of this capability can lead to over-allocating of resources or under-allocating resources when new conditions extend beyond the assumptions of a compliance-based rule. In either case, utilities and ratepayer resources would be utilized in a way that does not effectively improve safety as much as they could if these tradeoffs were properly addressed.

Limited incentive for regulated entities to learn and develop safety innovations: The goal of compliance-based regulation is to assure that systems are managed in a safe manner. In practice, however, compliance-based regulation can be seen as establishing safety and safe practices as opposed to a means of assuring safety. This subtle difference between regulation that establishes and enforces rules of safety, and regulation that strives to assure safety, can play a key role in shaping the safety culture of an organization. A compliance-driven safety culture is based on developing an awareness, skills, and expertise regarding known safety issues. Hazardous situations, however, can arise for many reasons, not all of which are known a priori. This focus on known safety issues drives compliance-based regulation to answer the question: "What do we need to do to comply with the safety regulations?" as opposed to a more proactive safety culture where the focus is driven to resolve uncertainties on unknown risks and ask the question: “What do we need to do in order to remain safe?”

Inclusion of Risk Management

The science of uncertainty and risk management has been recognized as a method that regulators and utilities can use to develop more robust and strategically focused safety programs[10]. This “risk-based” approach to safety regulation focuses on quantifying risk, which is defined as the product of the probability that a hazardous event occurs and the consequences if that event did occur.

$$Risk = Probability\ of\ failure * Consequence$$

By measuring both the probability and consequence of events, regulators and utilities can compare safety programs and projects with a common yardstick. This risk metric provides a consistent way to identify problems and establish priorities.

The top plot in Figure 1 illustrates how this paradigm might characterize two different types of events. One event is expected to cause major impacts to health and safety but has vanishing small probability of ever occurring (e.g. solar electromagnetic pulse event) and another event which may cause significantly less damage but could happen more frequently (e.g. transformer fire). A well designed and consistent risk metric would be able to compare these two disparate events against each other. Moreover, depending on how analytically rigorous this metric was, it could also distinguish the relative value of each risk and rank corrective actions that could be used to mitigate these risks.

The bottom plot in Figure 1 illustrates how a risk metric could also be used to evaluate different types of risk mitigating strategies. In this case, both strategy A and strategy B reduce the risk to the same level. Strategy A focuses on reducing the chance that an event will occur at all – the expected event frequency. This mitigation might involve some engineering fix or technology upgrade and might typically be the focus in a compliance-based approach to safety regulation. Strategy B, however, focuses on reducing the consequences that result if an event does occur. Risk-based regulation adds a new ability to value and score consequence mitigation on the same common yardstick as other engineering options. This added capability helps address the unknown sources of failures mentioned above. This can help make utilites more resilient since the consequences of failures are suppressed regardless of their cause.

[10] Risk Management is a mature field and has been adopted widely in many sectors of the economy. This section provides a brief over view of some of the key concepts that will be needed to develop risk based utility regulation. See the reference section for list of academic articles on risk analysis

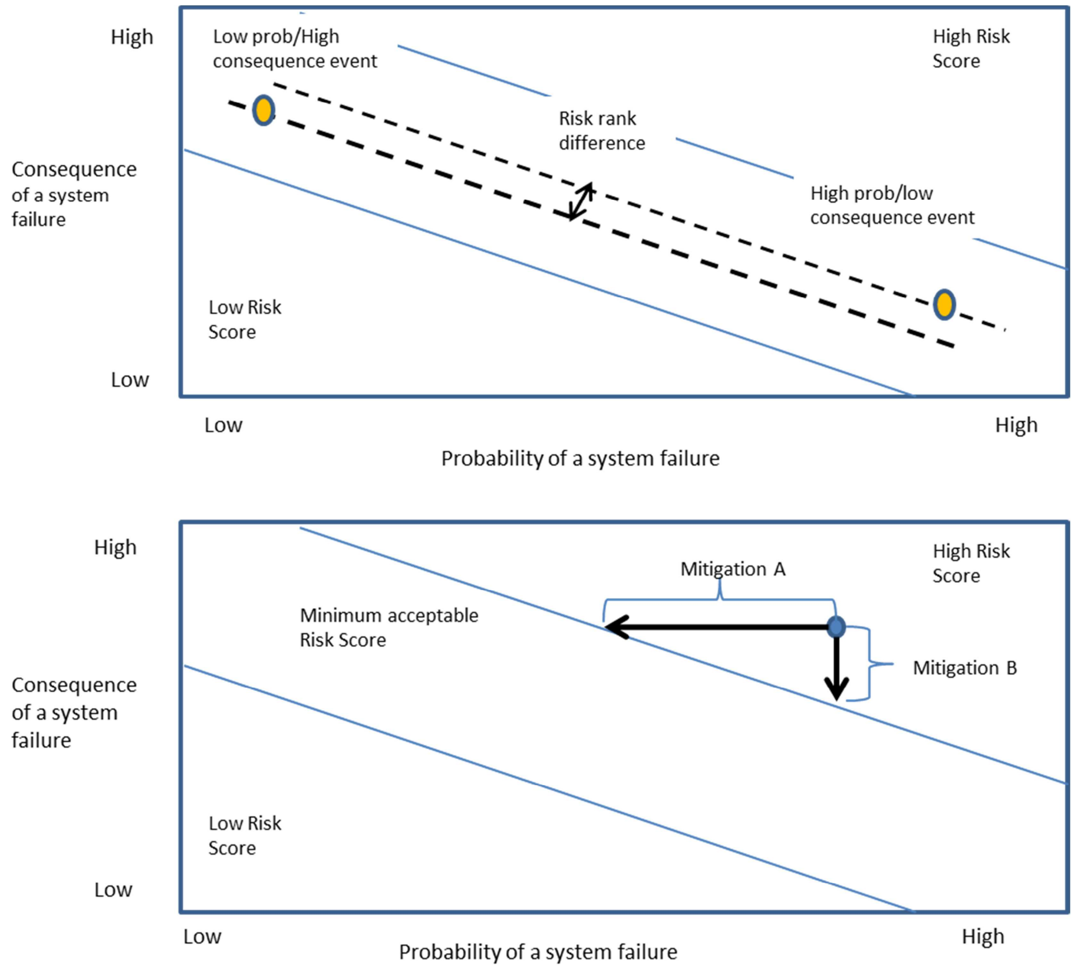


Figure 1 Risk Measures: Ranking risks against each other and comparing mitigation strategies

If there are no constraints on a budget, then both frequency mitigating and consequence mitigating strategies may be deployed. In a budget constrained environment, however, the risk-based regulation provides a clear metric for comparing several types of options and developing a coherent and cost effective strategy for mitigating risks. A risk-based regulatory strategy is based on developing a library of all risks. This risk library includes all the safety risks that a utility faces, the mitigation options that could be deployed, and then measuring them against a "common yardstick." A comprehensive risk library allows regulators, utilities and ratepayer advocates to assess multiple disparate risks and then establish safety priorities that are both analytically defensible and strategically based. The risk-based regulation goes beyond compliance-based regulations of single event, frequency driven failure analysis. Risk-based regulation is a more holistic approach than compliance-based regulation and allows regulators and utilities to develop long term strategies that are designed to build a system that is equally resilient to safety risks across the entirety of a utility.

Building this type of risk-based regulation not only requires an understanding of the engineering limitations but also why safety matters, i.e. the consequences. While utility managers certainly have more expertise with the systems they manage on a daily basis than regulators or ratepayers have, the consequences of failure can extend beyond a utility and impact the ratepayer and the public in general in many significant ways. Regulators and ratepayer advocates should play a key role in validating and corroborating how these consequences are estimated and valued.

IV. Seven challenges for building safety, security, and resilience into utility regulation.

While risk-based management has been successfully used in many other industries, incorporating a risk metric and the supporting safety culture into a comprehensive regulatory framework for utilities is unprecedented and presents several challenges. Unlike building a power plant or installing a new water main - whose technical specifications and system benefits can be clearly identified - installing a new safety system or program has much less well defined and measurable benefits. Building this safety culture also requires more than just a new metric or tool. Risk based regulation requires a long term commitment to developing skill sets, language, and processes between and among all stakeholders: utilities, regulators, and advocates.

1. Aligning safety performance across several industry functions

A risk-based metric can provide some level of assurance that a safety mitigating strategy - such as employee training programs or a pipeline test - can deliver on a promise of improved safety. Furthermore, a common risk metric, one that spans different systems and types of programs, gives regulators and utilities a powerful tool to compare a variety of programs against each other. Implicit in this assessment is that some programs will be identified as more valuable than others. In the private sector, this risk-based program discrimination is often measured against financial performance, such as the return on capital that a program or investment might provide. Valuing safety performance, however, is less well defined and requires a clear understanding of the value that improved safety provides to the public- *i.e.* how much safer are we because we invested in a program. Metrics such as number of injuries, hours of lost work, or loss of life are all ways to measure the effectiveness of a safety program. For the economic regulator, establishing priorities and determining which programs to fund and which ones not to fund requires that these metrics are consistent and truly reflect the public perception of the value of safety.

2. Balancing safety and other regulatory objectives

As much as we would want to reduce risks to zero, if assessed analytically that reduction would be impossible. Even if extreme, but possible, levels of risk reduction could technically be achieved, they often would call for unacceptable costs or major compromises to other core regulatory objectives (e.g. environment, reliable service, economic welfare of the state, reasonable rates). Managing safety risks along with several other core objectives creates another challenge. These other objectives must also be compared against safety programs. Programs designed to protect the environment, improve reliability of service, or increase the resilience of the network are core objectives that can be impacted by safety programs. Moreover each of these potentially competing objectives can also be valued on different scales (e.g. environment in tons of C02, safety in lost work hours, reliability in frequency of interruptions). Developing an intelligent risk regulation involves building an analytical framework for making tradeoffs between safety risks and other core objectives. Making those tradeoffs requires continuous scale and defensible risk metrics, such as those generated though a formal risk assessment process. Building a robust risk-based regulation process will require some methodology to value and make these tradeoffs.

3. Each stakeholder assess risks differently

The multi-objective problem not only spans different core mission objectives but also stakeholders. Risk assessments can and will be made by several different stakeholders, all of which will have different experiences, preferences and tolerances for certain types of risks. Each stakeholder may also value each core industry mission objectives differently and put more or less weight on some objectives over other ones. This is particularly an issue when risk assessments are done by the regulated firms on behalf of the regulator. While regulators can perform their own assessments, they must do so with considerably less direct knowledge of the real world practices, current conditions, and specific issues that may exist. Moreover, regulators are much less likely to have specialized safety and risk experts compared to the utilities. Third parties such as ratepayer advocates will have even less information about system risks even though they may be subject to the consequences of negative safety events. This information asymmetry between utilities, regulators, and ratepayers can create the perception, if not the reality, that utility driven risk assessments could be biased and systematically underestimate or overestimate the risks that exist. Even though each stakeholder may have a certain bias, they all bring important information to the risk assessment table. A robust safety regulation regime needs the capability to respond to this wide range of stakeholder perspectives and concerns while also being able to leverage the best information that each brings to the table.

Stakeholders in Safety Regulation

Investor owned utilities - As regulated monopolies, the consequences of safety failures limits their ability to maintain and maximize the efficiency with which they can deliver services. In these monopolies, the value proposition and incentives are typically provided for cost reduction and not safety innovation.

Economic regulator - Has a duty to maintain service at affordable rates. While they must approve funding for safety programs and projects, they operate with very limited information, expertise and oversight authority. The economic regulator must set rates that align the value of safety with the cost of service.

Safety regulator – Charged with setting and enforcing safety regulations. The safety regulator can typically issue fines and oversight but does not approve program funds. The safety regulation is currently managed separately from economic regulation.

Ratepayer advocates - Ratepayer advocates argue on behalf of ratepayers and the public and typically are focused on lowering rates.

4. Separation of safety program budgeting from safety oversight

The CPUC typically approves funds to mitigate safety risk – in the form of maintenance, repair and replace programs -through the General Rate Case (GRC) process. The GRC establishes the utility cost requirements and the rates that utilities can charge to recover these costs. A GRC is the major regulatory proceeding for California utilities, which provides the CPUC an opportunity to perform an exhaustive examination of a utility's operations and costs.[11]

The justifications for these programs and the rates required to recover those costs are typically vetted by an industry division within the CPUC - which we refer to as the economic regulator. This vetting process typically relies on historical figures for capital investment as well as operation and maintenance costs. The safety regulator, however, has not been significantly involved in this process. This separation between financing of safety mitigation and the management of safety risk can lead to some potential problems. As mentioned in the National Transportation Safety Board (NTSB) report on the San Bruno accident:

"If a safety improvement requires expenditure by an operator in an industry with no economic regulator, the decision is largely up to the operator. If the industry has an economic regulator, however, the economic regulator plays an important role in the operator's expenditure decisions. Hence, if expenditure is necessitated because the industry's safety regulator requires the operator to do something…" what result will occur if "… the economic regulator does not agree to some or all of the expenditure."[12]

In addition to the separation of economic and safety regulator within the CPUC, other safety regulators, such as the NTSB and the Nuclear Regulatory Commission (NRC), are also outside the typical funding process.

5. Compliance-based regulation and risk-based regulation at times contradict each other

Compliance-based regulation is typically based on specific engineering or operating specifications. While these standards may be based on sound engineering principles and operational experience, the rigid application of rules in real world situations can often fall short in mitigating actual events. The difference between a calculated hazard and an actual hazard depends not only on the condition of equipment but also on many other factors, such as personnel training, individual fatigue, and awareness of other hazards. A well intentioned procedure may be sufficient in many cases, but it is difficult to envision a priori how integrated risks play out in all possible scenarios. Risk-based assessment, however, is focused on developing an inventory of hazards and then ranking the relative risks that those hazards present.

[11] Typically performed every three years, the GRC allows the CPUC to conduct a broad and detailed review of a utility's revenues, expenses, and investments in plant and equipment to establish an approved revenue requirement.

[12] National Transportation Safety Board. 2011. *Pacific Gas and Electric Company Natural Gas Transmission Pipeline Rupture and Fire, San Bruno, California, September 9, 2010*. Pipeline Accident Report NTSB/PAR-11/01. Washington, DC. page 137

Due to these differences in the approach, a risk assessment may rank some compliance requirements lower than other risk mitigating practices. This can create a challenging environment for an operator who must comply with certain rules even though other risks may be more urgent. Incorporating a risk-based safety culture creates flexibility to empower utilities to act according to on the ground understanding of the actual risks, but still maintain rigorous oversight of standards and practice.

6. Leveraging information and building flexibility into safety regulations

Any risk assessment is made on the basis of incomplete information and requires some exercise of judgment. However, when new information becomes available, old assessments need to be updated. In some cases, the new information may show that a risk was overestimated and in other cases it may be underestimated. Risk-based regulation, at its most effective, is an iterative process and allows for changes in plans, priorities and budgets. This type of learning organization, with flexible planning capabilities, in many ways is counter-intuitive to compliance-based regulatory process which is often prescriptive in nature.

7. Valuing a safety culture and avoiding the safety whipsaw

In the wake of an accident, the impact and the human costs do not feel uncertain. The reactions can lead to programs and actions that may ameliorate a desire to act, but without any process for tracking improvement, setting new priorities, and valuing achievements these responses may not actually achieve persistent improvements to the safety and resilience of a utility. Conversely, when there is a pause between events, managers may underemphasize the value of safety programs and as a result safety programs may be seen as a cost savings center. This safety whipsaw leaves managers with little guidance about how to set and maintain long term safety and security priorities.

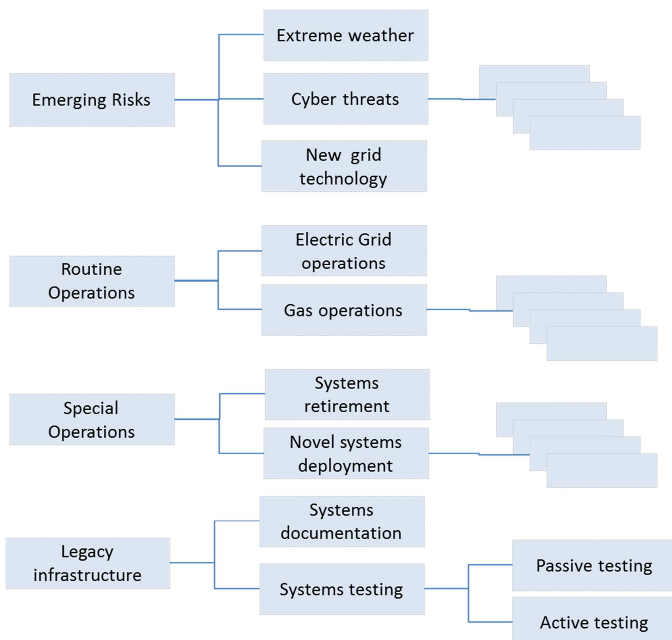
Moreover, this safety whipsaw points to a more pervasive problem, one where the core value of safety is left un-nurtured and without a champion. This problem is particularly acute in the regulatory environment where leadership changes are common and expected. In the CPUC, the five person commission rotates regularly as a result of staggered appointments, with a new commissioner entering the mix on an average of every 1.5 years. With the changing of the guard also come new agendas and priorities that reflect current issues and trends that span the full range of regulatory objectives not only safety. A safety culture, however, needs to transcend these changes and should reflect the core unwavering safety ethic of all stakeholders - the regulators, utilities, and ratepayers. The safety culture is resident within and permeates the language, the people, the processes, and stories that resonate through and define a culture. Fundamentally, a robust safety culture does not eclipse the other core missions that the commission faces, rather the safety culture should support and provide the base from which these new objectives can be launched.

V. Recommendations for building risk management as an approach to assuring safety, security and reliability

In view of these challenges, transforming to a risk-based regulatory approach will require a persistent effort, not only in the development of new tools but also in developing a safety culture and language.

1. Develop a risk taxonomy

We have mentioned that several different risks can be evaluated by a common metric, but we have not yet defined what those different risks are. We have mentioned several important risks such as downed power lines, transformer fires, small gas line leaks, and water contamination, but comprehensive risk-based regulation must be capable of handling an enormous variety of risks and in far more detail than discussed here. On the scale of a utility, building this risk library can be an enormous task. Approaching this as a hierarchy of risks that can be divided into classes of risk-based on common characteristics can make this challenge a manageable exercise. This divide and conquer approach forms a taxonomy of risks. It also naturally creates several sub problems that could be handled individually so that the most urgent problems could be addressed most quickly. A key feature of this hierarchical risk assessment process is that these separate sub class problems can be rolled up to achieve a more general and broad based evaluation of the overall risk that a utility faces.



2. Develop a model to score and compare risks

A library of risks is only half the challenge in developing risk-based regulation. Building a method to score the risks on a common yardstick is required to move from risk assessment to risk management. As mentioned above, when there is a single and easily measured objective, such as in financial risk management, scoring is essentially a problem of comparing the expected returns from an investment. When there are multiple objectives and missions, however, the expected returns are not as easily comparable. One way to combine these mission objectives is to quantify the utility - or weight - of each objective and then compare the utility of each objective against the other.

$$Score = Utility(Safety) + Utility(reliability) + Utility(resilence) + Utility(Environment)$$

3. Develop information requirements

Developing a risk library and risk model that represents the true conditions that exist requires information. Unfortunately perfect information does not exist and it is unreasonable to expect that it ever will. While it is certainly possible to develop risk models based on low quality data that might be readily available, regulators, with the cooperation of utilities, should develop a set of information specifications and requirements. These requirements should be designed to inform the risk management process and be sufficient to clearly delineate critical decisions that would be derived from those models. Clearly, a balance between having too little and irrelevant data and having information overload needs to be found. Likewise proprietary and confidential information should be respected while at the same time advancing the core missions of both the utilities and the regulator to provide safe and reliable service.

These information requirements should not be one-off types of information requests, but protocols for regularly, such as quarterly, sharing of information. The difficulties will be involved in designing the organizational, monitoring, recording (*i.e*. data collection), tracking, analysis and reporting steps called for to generate this data and any accompanying reports. This process also envisions monitoring all of those elements to make sure they are being appropriately executed and when appropriate sanctioned.

Developing a risk information protocol - for sharing, storing and protecting data - not only informs the model and the decisions derived from it but is also an important component in building a robust safety culture.

4. Identify roles in risk management

Regulatory risk management does not exist in a vacuum. It must work effectively within existing regulatory, management and institutional structures. A primary consideration is the clarity of risk management roles among institutions, in particular roles of regulation versus operation. In particular roles of risk management should be clearly identified and clearly allocated among all involved parties. These roles may include monitoring, recording, tracking, reporting, analysis, management, execution/operations, and review/oversight. Those eight roles can be most clearly specified and enforced within a risk-based regulatory structure that provides the analytic structure for collecting the data and processing it into risk scores.

The relationship between the regulator and utilities in a risk-based paradigm should also be addressed. This includes an analysis of the potential incentives of each stakeholder and the possible options that they may employ. Understanding the options that each stakeholder has in the risk-based regulation process should be addressed.

Conclusion

California, much like the rest of America, relies on aging electrical grid and natural gas pipeline systems. Similarly, regulation policies and practices have been managed via a prescriptive approach. However, the San Bruno tragedy highlighted a deficiency in this type of prescriptive approach. Since then, the CPUC has been actively working to advocate and enforce an evolution in the way utilities identify safety and reliability risks and justify the value of investments and operational expenses in relation to how well those risks are mitigated.

It is important to note that ultimately it is not “compliance” that is fundamentally the problem - rather, are the rules and regulations that are in place to mitigate risk, effective? In other words, are the rules that the entities are supposed to comply with any good? Secondly, are the cultures at both regulated entities and regulatory agencies sufficiently recognizing safety as the underlying principle for operation and achieving of objectives?

The CPUC is in the process of transforming to a risk-based regulatory approach which will require a persistent effort, and time to evolve and grow into this new approach.

References

Apostolakis, G. “The Concept of Probability in Safety Assessments of Technological Systems,” Science, New Series, Vol. 250, No. 4986. (Dec. 7, 1990).

Bier V, Lin, S. “Should the Model for Risk-Informed Regulation be Game Theory Rather than Decision Theory?” Risk Analysis, Vol. 33, No. 2, 2013.

Caputo C, Pelagagge P, Salini P. “A multicriteria knapsack approach to economic optimization of industrial safety measures,” Safety Science 51, 2013, 354–360.

Floyd H.L, “Toward a More Globally Effective Standard for Occupational Electrical Safety” IEEE, Paper No. ESW2009-17.

IAEA, “Risk informed regulation of nuclear facilities: Overview of the current status,” IAEA-TECDOC-1436, 2005.

Hamoud G, Toneguzzo J, Yung C, Wong A. “Assessment of Asset Safety Risk for Transmission Stations,” IEEE, 2006.

Keller M, Modarres M. “A historical overview of probabilistic risk assessment development and its use in the nuclear power industry: a tribute to the late Professor Norman Carl Rasmussen.” Reliability Engineering & System Safety Volume 89, Issue 3, September 2005, Pages 271–285.

Keeney R, Raiffa H. “Decisions with Multiple Objectives” Cambridge University Press, 1993.

Keeney R, “Valued Focused Thinking,” Harvard University Press, 1992.

Lanzisero T. “Applied Safety Science and Engineering Techniques: The ASSET Safety Management Process” IEEE, 2012.

National Academy of Sciences, “Review of the Department of Homeland Security’s Approach to Risk Analysis,” (2010).

National Transportation Safety Board. 2011. Pacific Gas and Electric Company Natural Gas Transmission Pipeline Rupture and Fire, San Bruno, California, September 9, 2010. Pipeline Accident Report NTSB/PAR-11/01. Washington, DC.

Paté-Cornell E, “Risk and Uncertainty Analysis in Government Safety Decisions,” Stanford University, 2002.

Cantor R. “How Fair Is Safe Enough? The Cultural Approach to Societal Technology Choice,” Risk Analysis, Vol. 7, No. 1, 1987.

National Research Council, “Risk Assessment in the Federal Government: Managing the Process,” Committee on the Institutional Means for Assessment of Risks to Public Health, 1983.

Tengs T, et al., “Five-Hundred Life-Saving Interventions and Their Cost-Effectiveness” Risk Analysis, Vol. 15, No. 3, 1995.

Von Neumann J, Morgenstern O. “Theory of Games and Economic Behavior” Third Edition 1953, Princeton University Press.